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MODIFICATIONS PROCESSING PROCEDURES: A GENERALIZED STOCHASTIC N--ETC(U)
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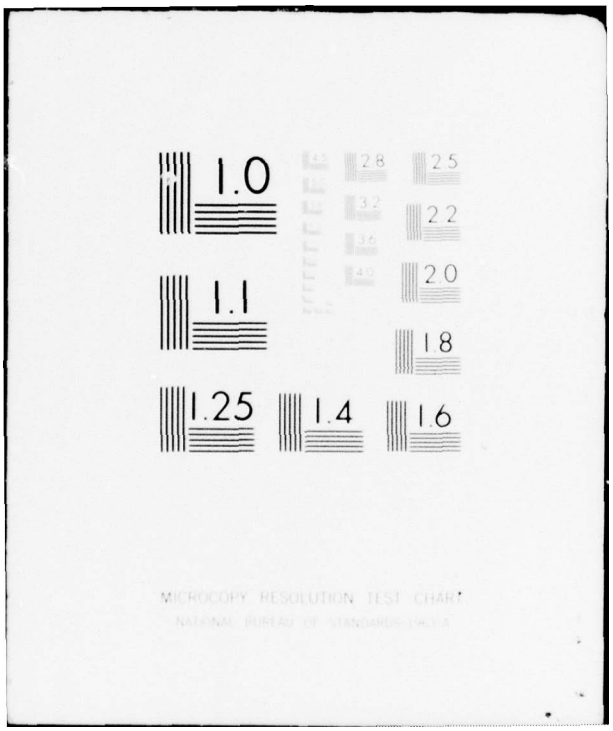
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TECHNICAL REPORT P-82
August 1977

MODIFICATIONS PROCESSING PROCEDURES: A GENERALIZED STOCHASTIC NETWORK MODEL

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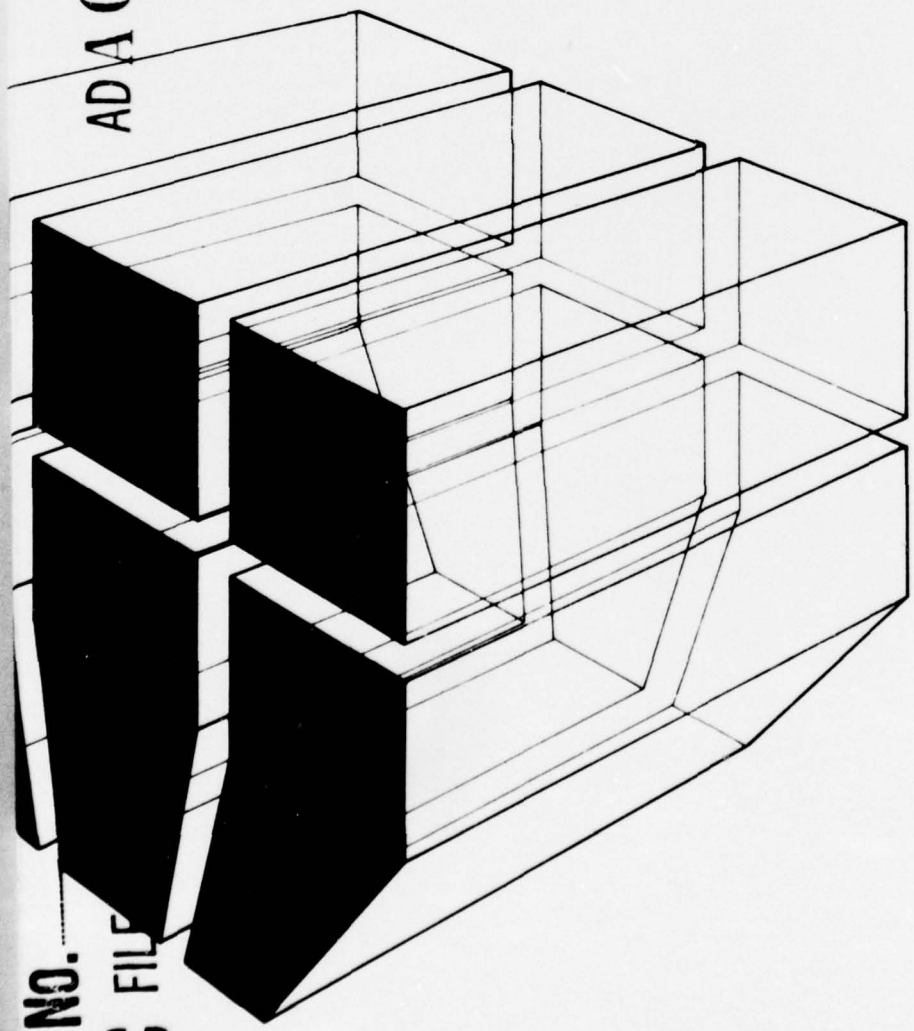

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modifications and claims

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This report discusses a generalized stochastic network model which incoporates the key features of the Corps of Engineers' contract modifications and claims processing procedures. The results of simulating the network model with two different levels of Resident Contracting Officer (RCO) authority are presented. The models and simulation provide a quantitative measure of the modifications and claims system's performance on which a quantitative evaluation of proposed system changes can be based.

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FOREWORD

This report summarizes research conducted under Project A4161101-A91D, In-House Laboratory Independent Research Program (ILIR), Task 04, Work Unit 055, "Modifications Processing Simulation." The work was performed by the Management Systems Branch (FAM), Facility Acquisition and Construction Division (FA), U.S. Army Construction Engineering Research Laboratory (CERL), Champaign, IL. The Principal Investigator was Mr. M. J. O'Connor.

Appreciation is expressed to Messrs. R. L. Foster and J. H. Hummel of CERL for their contributions to this project.

Dr. O. E. Rood, Jr., is Chief of FAM, and Mr. E. A. Lotz is Chief of FA. COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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1 INTRODUCTION

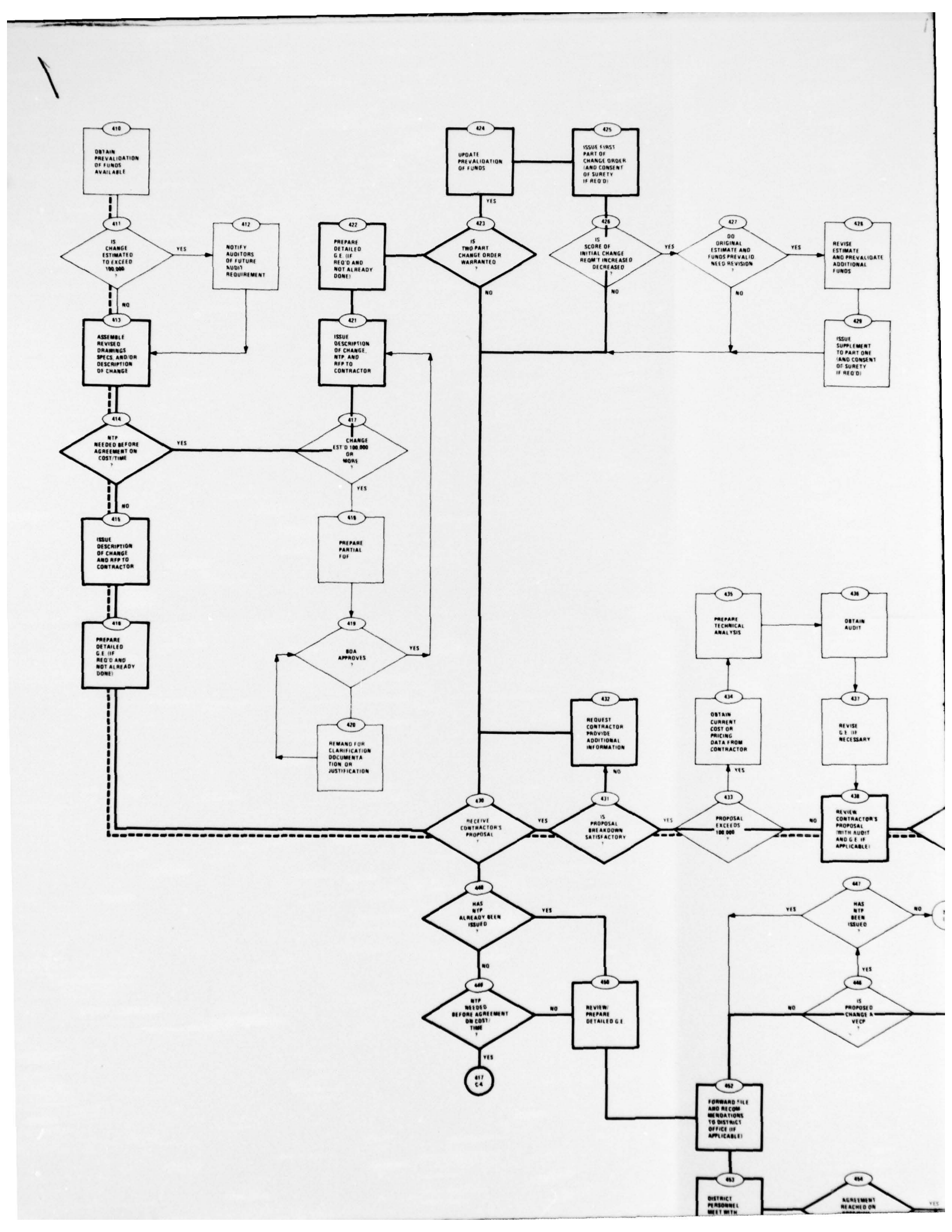
Background

A primary goal of the Corps of Engineers is to construct and deliver quality facilities in a timely manner at the lowest overall cost to the Government. Fixed-price construction contracts, which are normally used for this purpose, typically require modifications to complete a facility which functions properly and meets the user's needs. Therefore, the Corps' success in attaining its goal of lowest overall cost depends greatly on how effectively it executes contract modifications.

The procedures by which the Corps currently processes contract modifications are identified in Figure 1.[1] The actions and time required to process a particular modification depend on both the characteristics of the modification itself and on the total workload of the office processing it. For example, the requirement for a detailed Government Estimate depends on the dollar value of the modification (as identified by a budget/preliminary estimate). The time to prepare the estimate depends not only on the size and complexity of the modification, but also on the time and resources available to prepare the estimate.

This complexity makes it difficult to quantitatively evaluate proposed changes to the processing system. For example, it is generally believed that issuing a Notice to Proceed (NTP) before agreement on the cost and time of the modification results in a higher cost because the contractor has less incentive to reduce costs since he/she is essentially working on a cost plus basis. An alternative to issuing the NTP prior to agreement is to agree on the modification cost/time before issuing the NTP and incur the cost of impact on unchanged work that might accrue during the negotiation time. A reasonable rule for determining which procedure to use for a particular Change Order is to estimate the cost for both alternatives and use the least costly one. If issuing the NTP before agreement is the lowest cost alternative for a particular Change Order, and if the estimated cost of the Change Order is above the amount that the Resident Contracting Officer (RCO) can authorize, then the Contracting Officer (CO) must issue the NTP. This may increase the time required to issue the NTP and cause some impact

[1] *Modifications and Claims Guide*, EP 415-1-2 (Department of the Army, October 1976).


410
OBTAIN PREVALIDATION OF FUNDS AVAILABLE
411
IS CHANGE ESTIMATED TO EXCEED 100,000 ?
YES
412
NOTIFY AUDITORS OF FUTURE AUDIT REQUIREMENT
NO
413
ASSEMBLE REVISED DRAWINGS SPECS AND/OR DESCRIPTION OF CHANGE
414
NTP NEEDED BEFORE AGREEMENT ON COST/TIME ?
YES
NO
415
ISSUE DESCRIPTION OF CHANGE AND RFP TO CONTRACTOR
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PREPARE DETAILED G.E. (IF REQ'D AND NOT ALREADY DONE)
417
CHANGE EST'D 100,000 OR MORE ?
YES
418
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419
BOA APPROVES ?
YES
420
REMAND FOR CLARIFICATION DOCUMENTATION OR JUSTIFICATION
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422
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NO
441
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YES
450
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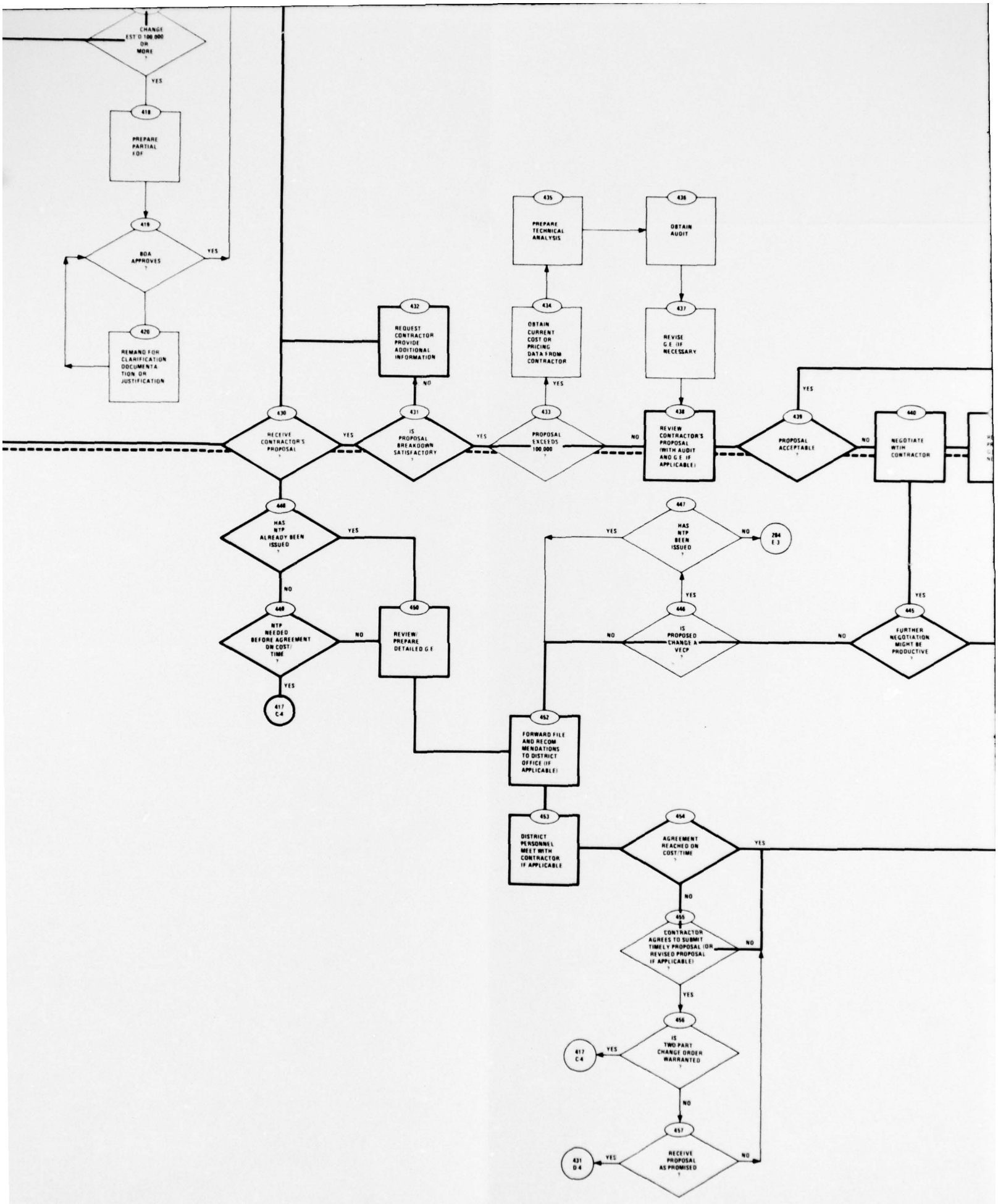
453
DISTRICT PERSONNEL MEET WITH
454
AGREEMENT REACHED ON
YES


CHANGE EST $100,000 OR MORE ?
YES
418
PREPARE PARTIAL FOF
419
BOA APPROVES ?
YES
420
REMAND FOR CLARIFICATION DOCUMENTATION OR JUSTIFICATION
435
PREPARE TECHNICAL ANALYSIS
436
OBTAIN AUDIT
434
OBTAIN CURRENT COST OR PRICING DATA FROM CONTRACTOR
437
REVISE G E (IF NECESSARY
432
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IS PROPOSAL BREAKDOWN SATISFACTORY ?
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433
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439
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NO
440
NEGOTIATE WITH CONTRACTOR
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445
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446
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NO
284 E 3
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449
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417 C4
450
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454
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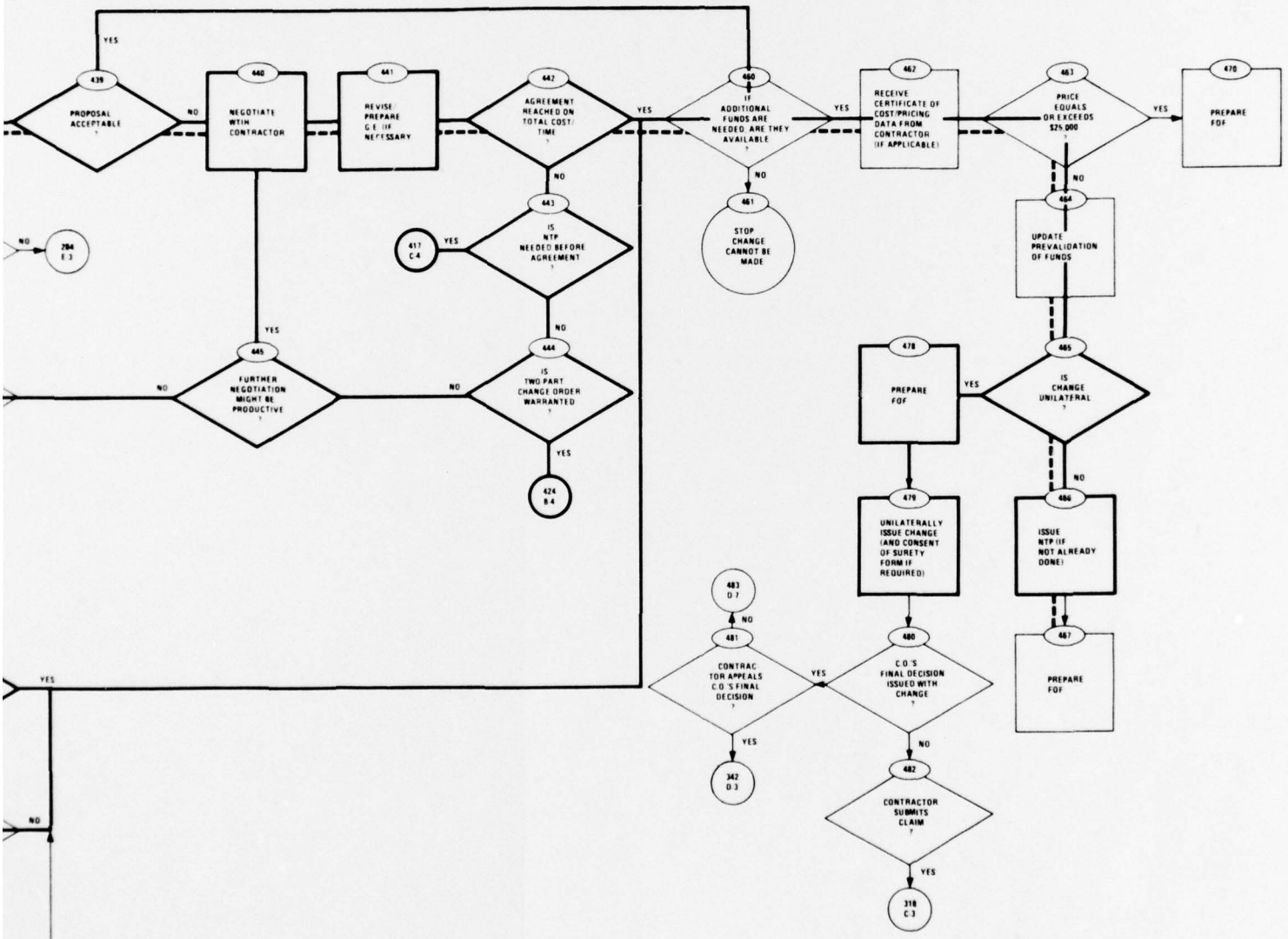
NO
455
CONTRACTOR AGREES TO SUBMIT TIMELY PROPOSAL (OR REVISED PROPOSAL IF APPLICABLE) ?
NO
YES
456
IS TWO PART CHANGE ORDER WARRANTED ?
YES
417 C4
NO
457
RECEIVE PROPOSAL AS PROMISED ?
YES
NO
431 D 4


439
PROPOSAL ACCEPTABLE ?
YES
NO
440
NEGOTIATE WITH CONTRACTOR
441
REVISE/PREPARE G.E. (IF NECESSARY)
442
AGREEMENT REACHED ON TOTAL COST/TIME ?
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NO
460
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YES
NO
461
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462
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YES
NO
470
PREPARE FOF
464
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465
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478
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479
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480
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481
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D-3
482
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318
C-3
466
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467
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443
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C-4
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444
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YES
NO
424
B-4
445
FURTHER NEGOTIATION MIGHT BE PRODUCTIVE ?
YES
NO
284
E-3
NO
YES
NO
NO

3

cost to be incurred. Quantitatively evaluating the effect that changing the level of RCO authority has on the total cost of negotiated Change Orders is difficult without the aid of a mathematical model.

Objective

The objective of this research is to demonstrate that mathematical modeling and simulation of the Corps' modifications processing procedures as a generalized stochastic network (i.e., a network with variable activity durations and precedence relationships, queuing, resource, and cost capabilities) can provide a means to quantitatively evaluate alternative modifications processing procedures.

Approach

To demonstrate how mathematical modeling can be applied to Corps operations, the processing of Change Orders under General Provisions Clause 3--Changes (GP-3) was modeled. Change Order processing was modeled from the point at which the need for the modification and the availability of funds has been established through either tentative agreement on a bilateral modification, or the issuing of a unilateral modification. The performance of a hypothetical Resident Office was simulated for two cases: (1) RCO authority for all modifications costing $10,000 or less, and (2) RCO authority for all modifications costing $25,000 or less. The total annual cost of each alternative, which includes the Resident Office operating cost and the negotiated Change Order cost, and the average time to process each modification were measured and compared.

Scope

The model developed in this study illustrates the capability of generalized stochastic network models to realistically model the critical features involved in processing modifications and claims. It does not include all activities required for processing modifications and claims; however, it does contain enough activities to exemplify the omitted activities and the structural relationship between the required activities. The simulation of the two levels of RCO authority is for example purposes only; this study is not intended to determine which level of RCO authority is most appropriate.

2 MODEL

General Description

The Modifications and Claims Flowchart (Figure 1) illustrates formally approved modifications processing procedures, as required by Armed Services Procurement Regulations (ASPR), Army Procurement Procedures (APP), Engineer Contract Instructions (ECI), and other official guidance.

Processing Change Orders of less than $10,000 under GP-3 were modeled from the point at which the need for the change and the availability of funds has been established (activity 413) through either tentative agreement on a bilateral modification (activity 466) or issuance of a unilateral modification (activity 479).

Simulation is required to evaluate this type of network system because analytical techniques are incapable of incorporating the network decision logic, queuing, resource constraints, and entity-dependent activity durations.

Network simulation basically involves:

1. Generating entities (initiating Change Orders).

2. Routing entities to the appropriate activity, based on the decision logic of the network and the entity attributes (requirements of the Corps' modifications processing procedures and the characteristics of the Change Order).

3. Queuing entities until the resources required to perform the activity are available (placing Change Orders in an "in basket" until the Office Engineer/Contract Administrator can process them).

4. Performing each required activity for a duration which is dependent on the attributes of the entity (review of contractor proposals of varying complexity, etc.)

5. Removing entities from the system when all the required activities have been completed (reaching tentative agreement on a bilateral modification or issuing a unilateral modification).

6. Collecting statistics on the system's performance (negotiated cost of the Change Orders and average time from initiation through completion of the Change Orders).

Detailed Description

The model was developed to reflect the performance of a hypothetical Resident Office which administers four or five Military Construction

contracts in the same immediate area. It was assumed that the Resident Office staff consisted of contract administrators who could perform all of the required activities. The model details for each activity are described below.

Change Order Initiation and Attributes

It was assumed that an average of 25 Change Orders is required on each project per year; hence, with five projects, approximately 125 Change Orders would be processed by the Resident Office annually. This implies that a new Change Order is initiated approximately every 2 work days. It was further assumed that this rate of Change Order initiation is constant throughout the year and that the number of Change Orders initiated in one week is independent of the number initiated in the previous week.

Change Orders were categorized as either field changes or District changes. Field changes, which include all changes identified and/or initiated in the field by either the Resident Office staff or the contractor, were assumed to account for approximately 75 percent of all Change Orders. District changes, which include all changes identified and/or initiated through the District Office either by the District Office staff or by Using Service request, accounted for the remaining 25 percent.

After the Change Order was categorized as either a field change or a District change, a base price and a critical start date for the changed construction work was assigned. The base price is defined as the fair and reasonable cost for the changed work. That is, the base price is what the negotiated cost of the Change Order should be if no impact cost on unchanged work is incurred and if the contractor is still working under the normal incentives inherent in negotiations before the change. Base prices for field changes were assumed to be distributed as shown in Figure 2 with a "most likely" cost of $4000, a minimum cost of $100, and a maximum cost of $25,000. Base prices for District changes were assumed to be distributed as shown in Figure 3 with a "most likely" cost of $10,000, a minimum cost of $5000, and a maximum cost of $75,000.

The critical start date for the changed construction work is defined as the latest date on which the contractor must be given the NTP to avoid incurring impact cost on unchanged work. The lead time (the time between the identification of the required change and the critical start date for the changed construction work) for field changes was assumed to be distributed in Figure 4 with a "most likely" time of 5 days, a minimum time of 0 days, and a maximum time of 20 days. District changes were assumed to have lead times distributed as shown in Figure 5, with a "most likely" time of 45 days, a minimum time of 0 days, and a maximum time of 75 days.

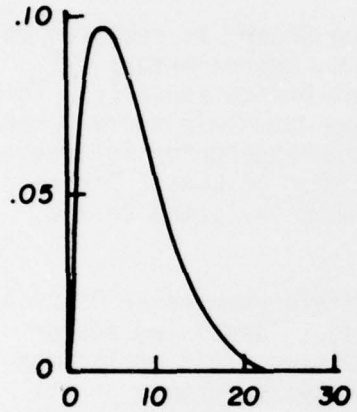

Figure 2. Field changes base price.

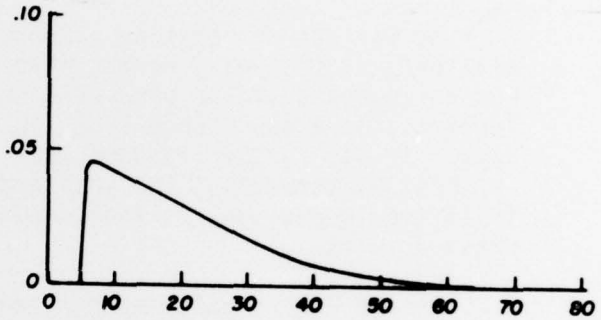

Figure 3. District changes base price.

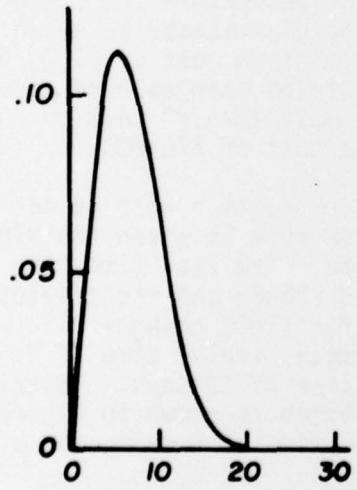

Figure 4. Field changes lead time.

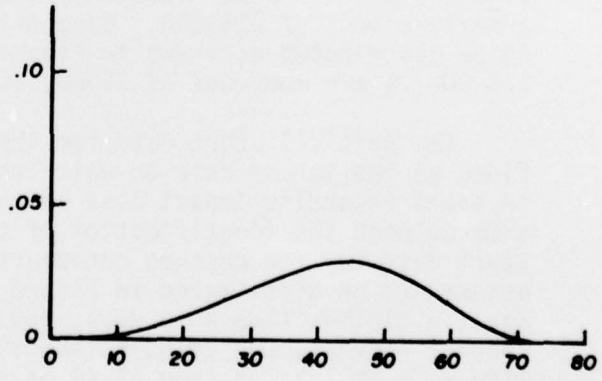

Figure 5. District changes lead time.

Activity 413: Assemble Description Change

The duration (the amount of actual productive effort to perform the activity) of activity 413 was assumed to depend on the complexity of the Change Order and whether the change was initiated in the field or the District. The base price of the Change Order was used as a measure of complexity. The average duration for a particular Change Order was established by multiplying a factor times the base price. Table 1 lists activity duration factors for all activities whose durations depend on the base price and the source of the Change Order. The variability of activity durations for similar Change Orders was modeled by establishing the actual duration for a particular Change Order as the average duration plus or minus some variation. The minimum actual duration for any activity was assumed to be 1 hour. The variation was established so that the actual durations would be normally distributed around the average and that 95 percent of the actual durations would be equal to the average duration plus or minus one-fourth of the average. Figure 6 shows activity durations as a function of base price and activity duration factor.

Table 1

Activity Duration Factors

Activity Number	Field Changes	District Changes
413, 416, 422, 450	1/4	1/8
424/425, 438, 478	1/8	1/8
440/441	1/4	1/4

In referring back to previous assumptions, it is noted that the duration of activity 413 for the "most likely" (base price = $4000) field change (75 percent of Change Orders) is 1 $\pm$ 1/4 days or 6 to 10 hours and for the District changes (base price = $10,000, 25 percent of Change Orders) is 7 1/2 to 12 1/2 hours. The durations for the minimum base price field change and District change are 1 hour and 5 $\pm$ 1 1/4 hours, respectively, and for the maximum base price, 6.3 $\pm$ 1.6 days and 9.4 $\pm$ 2.3 days, respectively.

All Change Orders were routed to activity 414 upon completion of activity 413.

Activity 414: NTP Before Agreement?

Activity 414 routes Change Orders requiring an NTP before agreement to activity 421 (activities 417 through 420 were excluded from the model since only Change Orders under $100,000 are involved) and Change Orders not requiring an NTP before agreement to activity 415. The need for an NTP was based on the expected time to reach agreement and the time

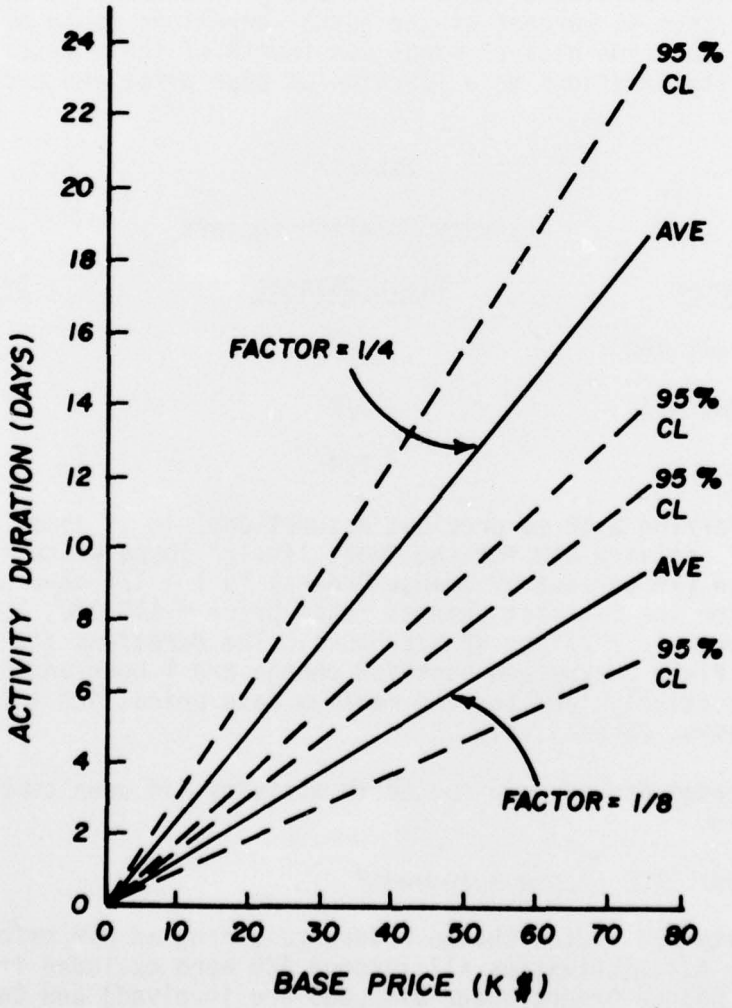

Figure 6. Activity durations.

remaining until beginning the modifications became critical. The expected time to reach agreement is equal to the time required to issue the Request for Proposal (RFP), plus the time the contractor needs to prepare his proposal, plus the minimum amount of time required after receipt of the contractor's proposal to negotiate and reach agreement. The time required to issue the RFP was assumed to be 1 hour if the Change Order was within the RCO's approval authority and was assumed to average 5 days if the Change Order was beyond the RCO's authority. It was further assumed that the contractor needs 1 day per $1000 of the Change Order base price and that the minimum time required to negotiate and reach an agreement is 1 day. An NTP was issued if the expected time to reach agreement exceeded the time remaining until the start of the changed construction work became critical.

Activity 415: Issue RFP

Activity 415 was assumed to require a constant duration of 1 hour for all Change Orders.

All Change Orders were routed to activity 416 upon completion of activity 415.

Activity 416: Prepare Detailed Government Estimate

Detailed Government Estimates (GE) were assumed to be required for all Change Orders exceeding the RCO's authority. The actual duration to prepare required GE's was established in the same manner as the actual durations for activity 413, with the average duration for field changes equal to one-fourth of the base price and one-eighth for District changes.

All Change Orders not requiring a GE were immediately routed to activity 430; the remainder were routed to 430 upon completion of activity 416.

Activity 421: Issue RFP/NTP

Activity 421 was assumed to require a constant duration of 1 hour for all Change Orders; however, the date on which the RFP/NTP was issued depends on whether the RCO or the CO issued it. If the RCO can issue the RFP/NTP, it is issued immediately. If the CO issues the RFP/NTP, a delay will be incurred. The delay for the District to issue the RFP/NTP was assumed to be distributed as shown in Figure 7, with a "most likely" delay of 5 days, a minimum delay of 1 day, and a maximum delay of 10 days.

All Change Orders were routed to activity 422 upon completion of activity 421.

Activity 422: Prepare Detailed Government Estimate

The requirements for and the duration to prepare a GE were established in the same manner as those for activity 416.

All Change Orders not requiring a GE were immediately routed to activity 423; all others were routed to 423 upon completion of activity 422.

Activity 423: Two-Part Change Order?

The probability that a Two-Part Change Order was warranted was assumed to depend on the base price as shown in Figure 8. The probability varies from 0 for a small Change Order to 0.50 for a $75,000 Change Order. Two-Part Change Orders were routed to activity 424; all others were routed to activity 430.

Activity 424/425: Revalidate Funds and Issue Part One

The combined duration for activities 424 and 425 was established in the same manner as that for activity 413, with the average combined duration equal to 1/8 times the base price for all Change Orders.

All Change Orders were routed to activity 430 (activities 426 through 429 were excluded from the model since they are of minor significance) upon completion of activity 424/425.

Activity 430: Receive Contractor's Proposal?

Activity 430 represents the time delay, if any, incurred while waiting for the contractor's proposal. As previously stated, it was assumed that the contractor needs an average of 1 day per $1000 of the Change Order base price. The actual time required by the contractor was established so that in 95 percent of the cases, the actual time would be plus or minus one-fourth of the average. For example, the contractor would typically need 6 to 10 days to prepare his/her proposal for an $8000 Change Order.

However, sometimes the contractor refuses to submit a proposal within a reasonable amount of time, particularly if he/she has already been issued an NTP. It was assumed that the contractor would not submit a proposal within a reasonable time for 5 percent of the Change Orders for which an NTP had not been issued and for 25 percent of the Change Orders for which an NTP had been issued.

Change Orders for which a proposal has been received were routed to activity 431 upon receipt of the proposal; Change Orders for which the contractor refused to submit a proposal were routed to activity 448 after waiting a reasonable time (minimum of 10 days, maximum of 1 1/4 times the average time required by the contractor).

Activity 431: Is Proposal Breakdown Satisfactory?

Ninety percent of the Change Orders were assumed to have satisfactory breakdowns and were routed to activity 438; the remaining 10 percent were assumed unsatisfactory and were routed to activity 432.

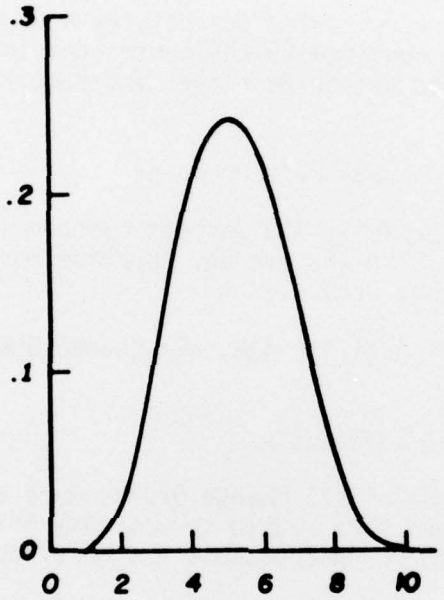

Figure 7. District delay.

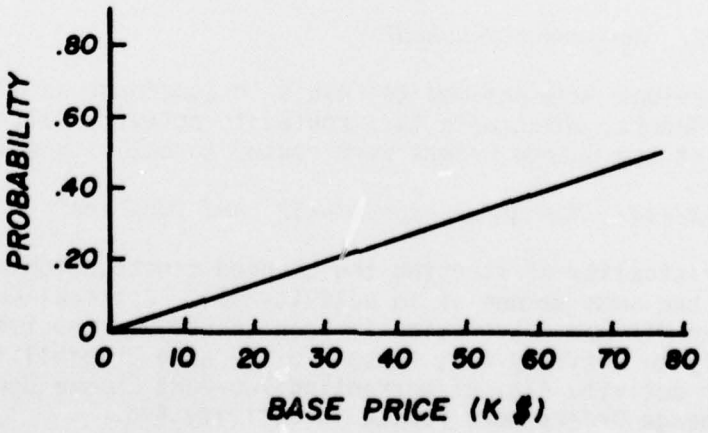

Figure 8. Two-part probability.

Activity 432: Request Additional Information

The duration of activity 432 was assumed to be 1 hour for all Change Orders.

All Change Orders were routed to activity 430 upon completion of Activity 432; the time required by the contractor to resubmit his proposal was established as one-half the time required for his initial submittal.

Activity 438: Review Contractor's Proposal

The duration for activity 438 was established in the same manner as activity duration 413, with the average duration equal to one-eighth the base price for all Change Orders.

Upon completion of activity 438, all Change Orders were routed to activity 439.

Activity 439: Proposal Acceptable?

Twenty-five percent of all Change Orders were assumed to have acceptable proposals and were routed to activity 465; the remaining 75 percent were assumed to be unacceptable and were routed to activity 440.

Activity 440/441: Negotiate and Revise GE

The combined duration for activities 440 and 441 was established in the same manner as that for activity duration 413; the average duration was equal to one-fourth the base price of the Change Order.

All Change Orders were routed to activity 442 upon completion of activity 440/441.

Activity 442: Agreement Reached?

Negotiations were assumed to result in agreement on 80 percent of the Change Orders, which were then routed to activity 460; the remaining 20 percent of the Change Orders were routed to activity 443.

Activity 443/444: NTP Before Agreement? And Two-Part?

The criticality of starting the changed construction work was checked in the same manner as in activity 414. Critical Change Orders for which an NTP had not previously been issued were routed to 421 and subsequently to activity 423; these had the same probability, as described for activity 423, of warranting Two-Part Change Order. Non-critical Change Orders were routed to activity 445.

Activity 445: Negotiate Further?

It was assumed that further negotiations might be productive for 80 percent of the Change Orders; these were then routed back to activity 440, and the remaining 20 percent were routed to activity 452.

Activity 448: Has NTP Been Issued?

Change Orders for which an NTP has already been issued were routed to activity 450; all others were routed to activity 449.

Activity 449: NTP Before Agreement?

The criticality of starting the changed construction work was checked in the same manner as in activity 414. Critical Change Orders were routed to activity 421; noncritical Change Orders were routed to activity 450.

Activity 450: Review/Prepare Detailed GE

The duration for preparing a previously unprepared GE was established in the same manner as in activity 416.

All Change Orders for which a GE was previously prepared were immediately routed to activity 452; all others were routed to activity 452 upon completion of activity 450.

Activity 452: Forward to District

The duration of activity 452 was assumed to be 1 hour for all Change Orders.

Upon completion of activity 452, all Change Orders were routed to activity 453.

Activity 453: District Meets With Contractor

The "most likely" elapsed time required by the District was assumed to be 10 days, the minimum 5 days, and the maximum 20 days.

All Change Orders were routed to activity 454 upon completion of activity 453.

Activity 454: Bilateral or Unilateral?

District negotiations were assumed to result in bilateral agreement 90 percent of the time, and unilateral for the remaining 10 percent. All Change Orders were routed to activity 465.

Activity 465: Is Change Unilateral?

Unliateral changes were routed to activity 478; bilateral changes were routed to activity 466.

Activity 466: Issue NTP (If Not Already Done)

The processing of Change Orders for which an NTP has already been issued was considered complete immediately. The activity duration for Change Orders requiring an NTP was assumed to be 1 hour. However, the date on which the NTP was issued was established as the current date if the Change Order cost was within the RCO's authority, or an average of 5 days later if the CO had to issue it, as in activity 421. The processing of these Change Orders was considered complete upon issuing of the NTP.

Activity 478: Prepare Findings of Fact

The duration for activity 478 was established in the same manner as activity 413, with the average duration equal to one-eighth times the base price for all Change Orders.

All Change Orders were routed to activity 479 upon completion of activity 478.

Activity 479: Issue Unilateral

The duration of activity 479 was assumed to be 1 hour for all Change Orders.

The processing of these Change Orders was considered complete upon issuing of the unilateral.

System Performance

To measure the performance of the modifications processing system, the Change Order cost and flow time and the elapsed time between initiation and completion were calculated for all Change Orders. Change Order costs were modeled as follows. It was assumed that Change Order cost increased, due to the impact cost incurred on unchanged work, if the NTP was issued after the critical start date for the changed construction work. The increase was assumed to depend on both the number of days past the critical start date that the NTP was issued and on the base price of the Change Order.

The solid line in Figure 9 shows the cost of Change Orders for which the NTP was issued after agreement as a function of the day on which the NTP was issued. For example, the Change Order cost for the "most likely" field change (base price = $4000) would be $4000 if the NTP was issued before the critical start date and would increase to

$8000 if the NTP was issued 20 days after the critical start date. The equivalent costs for the "most likely" District change would be $10,000 and $20,000, respectively.

It was further assumed that the loss of contractor incentive inherent in issuing the NTP before agreement would cause a penalty cost. Figure 10 shows the assumed penalty as a function of base price. The penalty was assumed to be 25 percent for small Change Orders and to decrease to a minimum of 5 percent for Change Orders over $20,000. The dashed line in Figure 9 shows the Change Order cost versus NTP date of Change Orders for which the NTP was issued before agreement. The cost of the "most likely" field change would increase from $4000 to $4840 if the NTP was issued before the critical start date and to $9680 if the NTP was issued 20 days past the critical start date. The equivalent costs for the "most likely" District change would be $11,500 and $23,000, respectively.

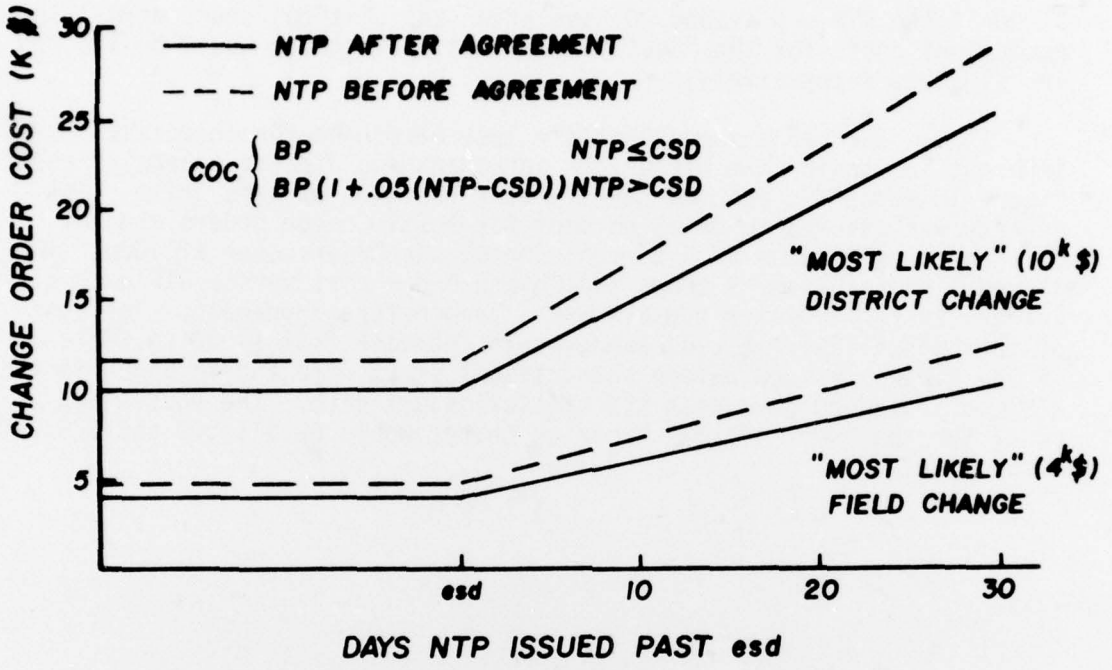

Figure 9. Change order cost.

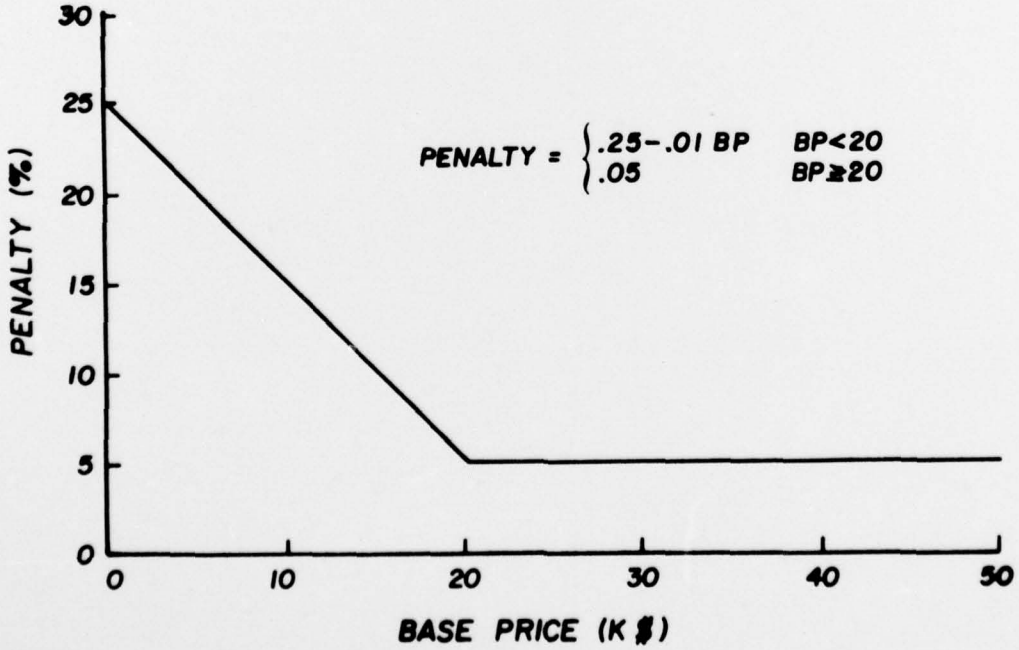

Figure 10. NTP before agreement penalty.

3 SIMULATION RESULTS

The model described in Chapter 2 was simulated for six 2-year periods (two levels of RCO authority, three staffing levels). During each simulation, the negotiated cost and the flow time to process each Change Order were calculated.

Table 2 presents the average cost per Change Order for both field changes and District changes and the average flow time with 95 percent confidence limits for the six simulations.

Table 2

Average Costs and Flow Time

RCO Authority $\leq$ \$10,000

Staffing Level	Change Order Cost ($000)		Flow Time (Days)
	Field Changes	District Changes	All Changes
3	10.2 $\pm$ .6	30.1 $\pm$ 2.6	37.0 $\pm$ 2.0
4	8.0 $\pm$ .4	21.7 $\pm$ 1.9	22.1 $\pm$ 1.1
5	7.6 $\pm$ .4	21.0 $\pm$ 1.7	20.1 $\pm$ 1.1

RCO Authority $\leq$ \$25,000

Staffing Level	Change Order Cost ($000)		Flow Time (Days)
	Field Changes	District Changes	All Changes
3	10.7 $\pm$ .7	27.5 $\pm$ 3.0	35.2 $\pm$ 2.2
4	7.7 $\pm$ .4	20.4 $\pm$ 1.6	20.5 $\pm$ 1.1
5	7.7 $\pm$ .4	20.4 $\pm$ 1.8	18.8 $\pm$ 1.0

When RCO authority was less than or equal to \$10,000, there was a significant reduction in both average costs and average flow time as the Resident Office staff was increased from three to four. A less significant reduction resulted when the staff was increased from four to five. The same trends were observed when the RCO authority was less than or equal to \$25,000. When the two cases are compared, it can be noted that the average costs and flow time are generally lower when the RCO has authority to issue modifications costing up to \$25,000.

If the total cost for each contract administrator is assumed to be \$40,000 per year and the same workload assumptions that were used in the model are made, the total expected yearly cost for all six simulations can be calculated (Table 3).

Table 3

Total Yearly Costs

Staff	RCO Authority ≤ $10,000 Total Yearly Cost (Million $)	RCO Authority ≤ $25,000 Total Yearly Cost (Million $)
3	2.01	1.98
4	1.59	1.51
5	1.57	1.55

When RCO authority is less than or equal to $25,000 and there is a four-person staff, a significantly lower annual cost results.

The example illustrates the capability of simulation for providing a quantitative measure of system performance (total yearly cost in this example) upon which proposed system changes can be evaluated.

This application of a generalized stochastic network model and simulation to the Corps' modifications processing procedures demonstrates the utility of mathematical modeling when evaluating changes to Corps procedures.

4 CONCLUSIONS

The Corps' modifications and claims processing procedures can be realistically modeled as a generalized stochastic network. Simulation of the generalized stochastic network can provide quantitative measures of system performance, thus enabling different system configurations to be evaluated quantitatively.